Study of the Financing of Graduate Medical Education

Report II
Hospital Cost Analysis

October 1986

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STUDY OF THE FINANCING OF GRADUATE MEDICAL EDUCATION

REPORT II

HOSPITAL COST ANALYSIS

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STUDY OF THE FINANCING OF GRADUATE MEDICAL EDUCATION

Preface

The Study of the Financing of Graduate Medical Education was conducted by Arthur Young and Company, prime contractor, and was sponsored by the Office of the Assistant Secretary for Planning and Evaluation in the Department of Health and Human Services. The project was initiated in 1980. Most data collection occurred during 1983 and 1984. Data processing and analysis continued through 1985.

The study was designed to address policy issues in the area of graduate medical education. The data base produced by the study, because of its detail and scope, should be a productive resource for years to come, and, as such, represents a primary achievement of the study. Analyses conducted by study participants are the other tangible product of the study. These analyses are documented in the series of reports listed below.

I. STUDY OBJECTIVES, DESIGN, AND DATA

Overview of the project -- issues, objectives; study design; description of sampling methodology; emphasis on description of data collected by the study.

II. AN ANALYSIS OF COSTS OF GRADUATE MEDICAL EDUCATION

Cost function analysis relating operating costs to teaching intensity as measured by resident-to-bed ratio, controlling for variations in various case-mix variables, including severity of illness.

III. SUBSTITUTION: ACTIVITY AND PRODUCTION FUNCTION ANALYSIS

Analysis of substitution and substitutability among residents, attending physicians, nurses, and other health professionals.

IV. CASE MIX AND QUALITY OF CARE: MEASUREMENT AND ANALYSIS

Detailed analysis of reliability and validity of alternative case mix and quality of care indicators collected by the study. (A Rand Corporation study.)

V. Part 1. FLOW OF FUNDS: CASE STUDIES

Examination of financing arrangements among entities in the hospital complex.

Part 2. EFFECT OF REIMBURSEMENT

Investigation of links between performance variables and mode of physician reimbursement (salary versus fee-for-service).

Public Use File

A large selection of the data collected and processed in the course of the project and described in Report I, will be made available for independent research in early 1987. For further information, write GME Project Officer, Office of Health Policy, Room 432E Humphrey Building, 200 Independence Avenue, Washington, D.C. 20203.

PROJECT PARTICIPANTS

Arthur Young and Company, (AY) the prime contractor for the Study, maintained overall management control during the entire course of the project. The company has been involved directly in on-site data collection, data processing, and analysis. Stephen Varholy, AY partner-in-charge, was project director during the largest part of the effort. Other Arthur Young & Company staff that made a significant contribution to the completion of the study or the preparation of the report included:

Robert J. Rourke
Susan Cosgrove
Katherine Douglass
Richard Frey
Dorne Hawxhurst
Alice Katz
Kevin Murphy
Teresa Roda
Nancy Southers

Policy Analysis Incorporated, (PAI) with company president Ralph Berry, Ph.D., assumed major responsibility for developing the study's analytic approach. PAI has also participated in on-site data collection and had responsibility for cost analysis. Other PAI personnel that were major contributors to the study include:

Mason Russell
Nancy Kelly, D.Sc.
Daniel Huse
Stacy Hubbard

The Rand Corporation, working under a separate grant, conducted case-mix and quality of care analyses beginning in 1984. The effort is under the overall direction of Robert Brook. Other Rand Corporation staff involved in the study include:

Toni Richards
Nicole Lurie
William Rogers

Others who were associated with the project in the early and middle stages include: Susan Horn, Ph.D., Johns Hopkins University; Dr. Dale Schumacher, Rockburn Institute; Mr. Stanley Jones, Health Policy Alternatives; Lewin and Associates, and Steven Eastaugh, D.Sc.

Technical Advisory Panel

The study was shaped and guided by a panel of experts. Members who remained in an active status through the project were:

Gerard Anderson, Ph.D., Associate Director
Center for Hospital Financing and Management
Johns Hopkins University

Thomas Delbanco, M.D., Director
Division of General Medicine and Primary Care
Beth Israel Hospital

Mr. Richard Knapp
Director, Department of Teaching Hospitals
Association of American Medical Colleges

Isidore Levine, M.D.
Deputy Director of Professional Affairs
Montefiore Hospital and Medical Center

Mr. Mark Levitan, President
Albert Einstein Health Care Foundation

Mr. Lawrence E. Martin
Associate General Director
Massachusetts General Hospital

Mr. Bruce Steinwald
Prospective Payment Commission

PROJECT OFFICERS

The first Project Officer and principal author of the concept and initial design of the study was Gerard Anderson, Ph.D. The final phase of the study and these reports were prepared under the direction of Stuart Schmid, Ph.D. Arthur Young & Company and Policy Analysis, Inc. would like to express their appreciation for the assistance that was provided by Drs. Schmid and Anderson and to acknowledge the contribution that both have made to the study.

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EXECUTIVE SUMMARY

This report, one of several based on findings from the Graduate Medical Education Financing Study, focuses on the comparative costs of teaching hospitals. The analysis undertaken addresses questions about the source of cost differences between teaching and nonteaching hospitals and, more generally, about patterns of behavior and cost variation among classes of teaching hospitals.

The methodology followed is that of traditional cost function analysis. A variety of independent variables of theoretical interest have been selected as factors explaining variation in operating cost per case from hospital to hospital. Regression techniques are used to estimate coefficients of the resulting cost functions.

Major Findings

The analysis confirms earlier research showing that teaching intensity, measured by resident-to-bed ratio, is clearly associated with higher costs of teaching hospitals, other variables, in particular case mix, having been taken into account. An increase in 1 resident per 10 beds is associated with an 8 to 10 percent increase in cost per case when costs are measured comprehensively to include non-salaried physician costs as well as costs flowing through the hospital. These results apply to the hospital level sample which is relatively small. For the much larger case-level sample, similar results obtain.

Severity of illness, as measured by the Susan Horn methodology, is found to have a statistically significant effect on cost after teaching effect, case mix, and other adjustment variables are taken into account. However, this relationship was found only for the case-level data.

A special analysis estimated the relationship between "indirect costs" per case and selected variables within a model analogous to that used in other research relevant to Medicare's indirect medical education payment to teaching hospitals. Coefficients obtained for the resident-to-bed ratio measure of teaching intensity for several alternative forms of the indirect cost model indicate a 7 percent increase for added resident per 10 beds--a rate close to earlier estimates.

I. Teaching Hospital Costs
Issues, Policy, and Prior Studies

Cost and Teaching Hospitals

Among the many characteristics by which acute care hospitals can be classified, none is more profound than the distinction between teaching and nonteaching hospitals. The teaching hospitals utilize the services of trainee residents and interns in the production of patient care. Through the supervised delivery of services, those residents and interns acquire essential graduate medical education (GME).[1] A majority of the largest hospitals are teaching hospitals, while most of the intermediate-size and essentially all the small hospitals (under 100 beds) are non-teaching hospitals relying for patient care on regular staff and attending physicians.

Among the teaching hospitals, the extent and intensity of teaching (as might be measured by the number of residents relative to the number of beds) varies widely. The median teaching hospital has on the order of one resident per 10 to 15 beds, but most trainees are concentrated in teaching centers where the number of residents and interns is well above one per 5 beds. This report focuses on the cost implications of this wide variation in method of producing patient care services.

Simple comparisons show that teaching hospitals are significantly more costly on a per-case basis than nonteaching institutions. Average per-case cost for the 115 largest teaching hospitals was $3,705 in 1981. A comparable average for non-teaching hospitals was $1,698 (Commonwealth Fund, 1985). Significant teaching-

[1]Throughout this report, the term "residents" will be used to embrace first year graduate medical students--interns--as well as more advanced students.

nonteaching cost differentials persist when hospitals are sorted by bed size (Association of American Medical Colleges, 1982).

Two types of explanation may be advanced for the phenomenon of higher costs at institutions using trainee labor. One is that the cost differential is due to independent factors that happen to be correlated with the teaching-nonteaching distinction. A second possibility is that the teaching process itself tends to increase costs in some manner.

Independent factors that might explain much of the difference include the following. (1) Teaching hospitals handle more complex, expensive cases. (2) Teaching hospitals are the locus of research, and some research cost may be mingled with patient care costs. (3) Teaching hospitals tend to be larger, and thus may be subject to diseconomies of scale. (4) Teaching hospitals may tend to be concentrated in urban areas where labor costs are higher.

The larger the proportion of apparent cost difference that can be explained by correlated factors, the more plausible is the proposition that the presence of graduate medical education programs in a hospital does not contribute to higher costs. The reasonableness of this proposition stems from the fact that residents perform services that would otherwise be done by nurses, salaried staff physicians, and attending physicians. This is the plus side of the ledger. On the negative side, as noted below, the teaching process may have an adverse effect on efficiency and may also produce higher intermediate costs, for example, in the form of redundant lab tests. If teaching and non-teaching hospitals competed with each other on the basis of price, then any "inefficiency costs" of teaching would have to be offset in one way or another by teaching hospitals in order to compete. One possible adjustment would be to lower resident salaries below their market value, that is, what the resident could earn in independent practice at his or her current

level of training.[2] The industry until very recently has been insulated from price competition. As is still generally the case, choice of hospital is often left to the physician. Most or all of the hospital bill is paid by insurers and government payers. Only very recently have these payers taken an active interest in comparative costs of different hospitals. In an environment of payer indifference, it is not possible to hypothesize that high costs due to teaching would lead to offsetting adjustments in resident salaries.

A number of studies have demonstrated that the teaching process introduces cost-increasing inefficiencies and duplication into the patient care process. Residents interact with other workers in ways that can increase the overall workload. Residents order extra laboratory tests and x-rays. Procedures performed by residents are often repeated by attending physicians. (Busby, Leming, and Olsen), (Schroeder and O'Leary). If the presence of residents in teaching programs lowers costs on balance, it must be in spite of these effects.

Adding yet more ambiguity, it is necessary to recognize that an analysis of the effect of GME on overall economic cost may be felt beyond the hospital itself. Payments made to attending physicians do not flow through the hospital accounts, so any substitution of residents' services for work that would have otherwise have been performed by attending physicians is not credited to the teaching hospital. Considering only variation in costs visible to the hospital will give an exaggerated indication of the higher costs of teaching hospitals.

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[2] As a general proposition, economic theory would predict that workers acquiring on-the-job training that can be transferred to other firms would, in effect, pay for that training in the form of lower wages (Becker, 1975). As for hospitals, one study found evidence that resident salaries were lower than market value (Feldman and Yoder).

Policy Issues. Because teaching hospitals exhibit higher costs, the federal government, persuaded that teaching is costly, offers special subsidies to reimburse for services rendered to Medicare patients. Recently adduced evidence that these subsidies are in part statistically unwarranted (Anderson and Lave) and Congress' desire to reduce federal outlays, have created pressure for (and recently enactment of) cuts in government support for GME. Non-government payers are also beginning to balk at covering higher teaching costs. Blue Cross is the second most important buyer of hospital services in the nation, and in many areas pays hospitals on a cost-reimbursement basis similar to the former practice of Medicare. It is now shifting in the direction of paying hospitals prospectively. Commercial insurance carriers, traditionally passive payers of charges, are now developing a "prudent buyer" (i.e. rational price-conscious) mode of behavior.

Recent policy debate seems to reflect a desire to restrict government financial support for teaching hospitals to a level corresponding in some sense to the "true" incremental costs of teaching. Some critics believe government and third party payers should pay teaching and nonteaching hospitals the same price for similar services, if necessary decreasing resident salaries to make teaching hospitals competitive. Uncertainties regarding origins of teaching hospitals' higher costs and doubts as to the comparability of services among different classes of hospitals fuel the debate.

Medicare prospective payment. As it happens, these and other issues have been forced more prominently into the policy agenda as the implications of new Medicare prospective payment policy work through the industry. In earlier times, third-party payers could be expected to support high-cost teaching hospitals, in effect subsidizing whatever it was about those hospitals that caused costs to exceed average costs in non-teaching hospitals. The era ended with Medicare's shift from a retrospective payment system to a prospective payment system (PPS).

With most Medicare dollars now flowing to hospitals in accordance with a fixed diagnosis-related price arrangement, the higher costs of teaching hospitals must be accommodated explicitly. Medicare pays a share of resident salaries, and, in addition, provides supplemental payment based on the "intensity" of teaching. The higher the ratio of residents to beds in each hospital, the larger the add-on Medicare payment. (The methodology of the payment is discussed in more detail in a later section.)

Early Teaching Hospital Cost Studies. The present study follows in the wake of many earlier investigations of graduate medical education costs. A number of studies focus on the effect of GME on specific hospital expenses such as laboratory utilization. Some study the substitution effects as residents participate in the hospital production process. Others take a more general approach. A selective review of some of these studies is presented below.

Among the more general investigations of teaching hospital costs, most have found that the presence of teaching programs increases the cost of patient care. Carr and Feldstein (1967), one notable example from the early cost literature, used multiple regression analysis on hospital costs at 3,147 short-term U.S. hospitals. They concluded that hospital-medical school affiliation, numbers of interns and residents, and numbers of residency programs in these hospitals were significant factors in explaining cost differences among hospitals.

Ingbar and Taylor (1968) found that costs per available bed day (ABD) were higher for the majority of services provided in teaching hospitals than in non-teaching hospitals. Based on their analysis of 72 Massachusetts hospitals, they found that service costs per ABD in teaching hospitals were more than 20 percent higher than in non-teaching hospitals.

In a study of patient care costs of stroke victims in teaching and community hospitals, Feigenson et al. (1978) found mean costs of

care to be 50 percent greater in the teaching institutions. This study has been criticized, however, for not controlling adequately for case mix differences across sample hospitals, since patients treated in teaching hospitals had appreciably greater dysfunction resulting from their illness than others whose costs of care were studied.

Eastaugh's 1979 study of the impact of teaching on costs and utilization in a sample of patients (matched by diagnosis, age, preadmission work and other characteristics) in VA and non-Federal hospitals, found that a 25 percent decrease in surgery residents was associated with a 5.3 percent decrease in cost per case.

One small-sample study found that costs in the teaching hospital were lower, other factors held constant. Neu (1976) compared diagnosis-specific Medicaid case costs, including physician billings, in one major teaching hospital and four other hospitals. He found total costs to be 10 percent lower in the teaching hospital, a result that reflected one-third lower physician-billed costs. (It may be that the lower apparent costs are due to a tendency for physicians to omit billings for indigent patients.)

Resource use. Several studies looked at the effect of teaching on processes, providing some insight on how costs might be effected. Busby, Leming and Olson (1972) found that one sample of teaching hospital cases exhibited on average, 90 percent more laboratory tests, 95 percent more x-rays and 25 percent more electrocardiograms than comparable cases in non-teaching hospitals.

Martz and Ptakowski (1978) compared charges generated for "teaching patients" and "non-teaching patients" in the same teaching hospital, and found major differences in ancillary charges other than drugs. Laboratory charges were found to be 160 percent higher among teaching patients than among non-teaching patients. In general, greater volume rather than use of more expensive tests explained the difference.

Case mix. Among the collateral effects on teaching hospital costs, differences in case mix has proven one of the most difficult to disentangle. Thompson et al. (1974) reported that case mix differences accounted for more than 77 percent of the cost difference between Medicare patients in major teaching and non-teaching hospitals in Connecticut, implying that the impact of teaching per se is smaller than previous studies may have indicated. Similarly, Garber et al. (1984) noted that case mix differences across only 12 diagnosis related groups (DRG's) accounted for the bulk of the cost differential observed between teaching and non-teaching patients in a major university hospital. In contrast, though, Frick, Martin and Schwartz (1985) found that case mix differences alone explained only about one-fourth of the higher costs associated with teaching hospitals.

Horn and Schumacher (1981) compared severity-of-illness levels and treatment patterns of patients with acute myocardial infarction in a major medical center and a nearby community hospital. The results suggested that apparent cost differences are partly due to different complexity of cases.

Substitution. Substitution among residents, nurses, and other physicians in teaching hospitals, a phenomenon which should have an important bearing on cost effects of GME, has been examined by Massell and Hosek (1975). They examined substitution of interns and residents for experienced physicians in radiology departments of Veterans Administration hospitals. Their analysis suggested per-unit cost savings due to use of residents. The study did not attempt to identify or measure any offsetting cost increments due to greater service intensity.

Recent Cost Studies

A multivariate analysis of a relatively large sample of hospitals by Sloan, Feldman, and Steinwald (1983) found that teaching

hospitals as a class (members of the Council of Teaching Hospitals) incurred non-physician costs 13 percent higher than nonteaching hospitals, other factors including case mix being held constant.

Cameron (1985) is, in a sense, a precursor to the present study because of essential similarities. Drawing on a large sample of Medicaid patients in California, Cameron merged separately-billed fee-for-service physician charges with the hospital bill to produce a comprehensive total cost measure for each case. Hospital cost per case was derived from charges using a cost-to-charge ratio adjustment. (The present study uses, instead, a more elaborate accounting methodology to compute costs.) Cameron controlled for case mix variation using a DRG index adjustment.

Costs were then compared for three types of teaching hospital and non-teaching institutions. A strong relationship between cost per case and teaching intensity was found, explainable only in part by case mix differences and physician compensation. Cost per case was 28.4 percent higher than average in university teaching hospitals, 9.9 percent above average in major teaching hospitals, equal to the average in minor teaching hospitals, and slightly below average in non-teaching hospitals. Average costs per case in university hospitals were found to be 56.7 percent higher than in the non-teaching hospitals. A similar but weaker pattern was found when non-teaching hospital costs were compared to hospitals with less intense teaching activity.

Statistical analysis of Medicare cost data. Medicare policy issues has in recent years led to a specialized series of analyses. The objective has been to measure the incremental cost associated with teaching intensity when other factors are held constant. The measure would then be used to adjust Medicare payments to teaching hospitals. Analyses carried out by the Health Care Financing Administration (Lave, 1985) provided the quantitative underpinnings of "indirect teaching cost" payments to teaching hospitals. Recent contributions (Anderson and Lave, 1986, and Commonwealth Fund,

1985) have provided further insight into the relationships of interest.

II. Data and Methodology

Data Base*

The analysis uses data collected from a cross-section of 45 hospitals. Of the 45, 36 were teaching hospitals spanning a broad range of size and teaching intensity. Design of the data base reflects a number of objectives other than the cost analysis reported here (See Preface). Of particular interest for the cost analysis is the extensive data on cost and a variety of other information useful in separating the effects of the teaching process from other characteristics of hospitals, in particular, characteristics that are correlated with teaching.

The data collection effort has provided a data base of unprecedented scope and detail. In addition to elaborate cost and revenue information from 45 hospitals, a wide variety of descriptive collateral information pertaining to hospitals, departments, teaching activity, and characteristics of sampled patient cases are included. Case data includes multiple measures severity of illness and quality of care for each of more than 25,000 patients. Data elements apply to one or more of three levels of detail: hospital, clinical department, and case. (Only hospital and case level data is used in the cost analysis reported here.)

At each hospital, financial and medical records information was collected for each of 575 admissions. Of these, 375 were randomly selected from the full set of admissions during the year. The 375 consisted of 75 cases from each of five departments defined for the study (medicine, surgery, obstetrics/gynecology, pediatric and "other"). Departmental assignments were made on the basis of ICD-9-CM diagnosis and procedure codes from the Uniform Hospital Discharge Data Set (UHDDS) tape obtained from each hospital.

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* The reader is referred to Report I for a more detailed description of various data components.

An additional 200 cases were included in the sample to obtain 25 cases in each of eight diagnostic groups. The diagnoses were chosen by a panel of medical advisors as representative of an "average" admission in each of the five clinical departments. These cases were selected in the same manner as the random cases. The diagnoses, listed by department classification, were:

Medicine	- acute myocardial infarction
	- upper GI hemorrhage
Surgery	- gallbladder disease with cholecystectomy
	- benign prostatic hypertrophy
OB/GYN	- complicated delivery
	- hysterectomy
Pediatrics	- acute gastroenteritis
	- asthma

Case costs. Abstracts of the sample records were prepared on site by accredited medical records technicians. A copy of the bill for each patient was obtained on paper, microfiche, or magnetic tape. The medical record information and matching bill constituted the case level file.

Costs for individual cases in each hospital were constructed in the following way. First, hospital cost accounts were audited and distributed among 26 standardized cost centers. Procedures that generated the bulk of charges in a hospital--typically 1,000 from a total of 3,000 identifiable procedures--were translated into relative value unit measures of resource use. RVUs for each cost center were assigned "prices" by dividing total cost center costs by the total volume of corresponding procedures recorded in the hospital revenue and usage reports.

With this information, each patient bill among the cases sampled in a hospital was translated into a cost record by multiplying specific procedures listed in the bill by a corresponding number of RVUs and by the hospital-specific RVU "prices." (This procedure could not be used for the pharmacy and medical supplies cost centers because hospital records were provided inadequate detail. Instead, a cost-to-charges ratio methodology was followed for these items.)

Physician charges and costs for non-salaried physicians were not available directly, necessitating the use of surrogate charges for this component of total cost. To impute charges, an inventory of physician-administered procedures was prepared for each patient using ICD-9-CM coding and the medical record. A standard schedule of physician charges for these procedures was adjusted for location using Medicare prevailing charges information. The procedure was validated by comparing the results with the charges recorded by two hospitals in the sample that did include physician bills in available records.

Medical record data. The cost analysis is able to draw on several different case mix data elements for purposes of controlling for variations among the hospitals in the sample. Case mix measures include Diagnosis-Related Groups (DRG's), Disease Staging (Gonnella, 1983, 1984), and Severity of Illness (SOI) (Horn and Sharkey, 1983). DRGs are assigned to each case in the sample, and DRG indices are included in department and hospital level files. Disease staging developed by SysteMetrics was used to classify cases in the random sample of cases of each hospital. A Severity of Illness Index value was assigned to each of the 575 cases sampled for each hospital. Length-of-stay (LOS) for each case is the final variable to be used in controlling for variation in mix of cases.

Measures of quality of care used in the analysis include an adverse patient occurrence index inventory and selected process and outcome indicators.

Hospital sample and categories (typology). The 36 teaching hospitals in the sample were determined on a stratified random procedure that provided a cross-section in terms of teaching type and geographic location. The nonteaching hospitals were substratified only by bed size.

In order to assure a sample of the desired degree of representativeness, the universe of teaching hospitals was divided into four groups varying by a number of characteristics associated with teaching intensity. (See discussion of typology in Report I of the study series.) The sample frame was then stratified by selecting a set number from each of the four groups. Table 1 describes the sample hospitals by group according to selected criteria used originally to define the groups. Table 2 compares the resulting groups according to average values of descriptive variables of interest for hospitals in each group.

The original study plan was to use teaching status as determined by assignment to one of the four groups described in Tables 1 and 2 as the primary measure of teaching intensity in the cost analysis. As it turned out, resident-to-bed ratio, a continuous variable that has been used as a measure of teaching intensity in a number of recent studies and administrative applications, was found to more satisfactorily explain variations in cost than the discrete type variable and, for this reason, was used exclusively in the analysis.

TABLE 1

TEACHING INTENSITY MEASURES OF SAMPLE HOSPITALS, BY TYPE
(AVERAGES PER HOSPITAL)

VARIABLE	GROUP			
	1	2	3	4
Number of Residents in 7 Large Specialties	9.7	17.5	56.6	134.2
Number of Residents in 19 Medical and Surgical Specialties	5.5	0	13.1	70.3
Number of Residents in Family Practice	7.0	17.8	13.3	13.4
FTE Salaried Faculty	6	20	53	400
FTE Volunteer Faculty	158	28	204	288
FTE Board Certified Teaching Physicians	21	11	47	166
FTE Salaried Faculty Per Resident	0.2	0.7	0.6	1.2
FTE Volunteer Faculty Per Resident	7.0	0.9	2.3	0.8
FTE Board Certified Teaching Physicians Per Resident	1.0	0.4	0.5	0.5
Number of RN (Dipl.) Students	81.3	110.0	63.5	141.0
Number of Nursing (Bac.) Students	20.5	65.6	73.3	132.4
Number of LPN Students	0.8	55.9	55.3	21.9

TABLE 2

SELECTED COST AND CASE MIX MEASURES
BY HOSPITAL GROUP
(CASE LEVEL DATA)

VARIABLE	GROUP			
	1	2	3	4
Mean Cost Per Case ($)	3,541	4,098	3,885	5,938
Weighted DRG Index	0.87	0.88	0.89	1.02
Mean Length of Stay (Days)	6.6	7.1	7.8	8.4
Mean Severity Level	1.50	1.49	1.48	1.55

III. Model Specification

Cost Function Analysis

The cost analysis applies standard econometric techniques to estimate coefficients describing a hospital cost function. An economic cost function expresses a hypothesized mathematical relationship between the dependent cost variable and one or more independent variables. A hospital cost function represents a highly distilled description of how hospital costs vary in response to changes in the way hospitals are organized and operate (for example in scale of operation), or in response to differences among hospitals in terms of their economic environment (for example, local labor costs).

The variables included in the cost relationship are those thought to be important in explaining observed differences in cost. Conceptually, describing the hospital industry in terms of a cost function presumes that any combination of values of the independent variables dictates a unique value of the dependent variable.

A typical hospital cost function might postulate cost to be a function of:

average cost (cost per unit of output);
quantity of output, scale, or capacity utilization;
input prices;
case mix;
teaching status or intensity;
patient demographics, hospital descriptors, etc.

The usefulness of this approach depends on the ability of the analyst to hypothesize a relationship that explains the relevant data. A satisfactory test of any hypothesis depends, as well, on the availability of a sufficiently large and diverse set of observations of the variables included in the equation.

Selection of independent variables, together with a specification of the shape of the cost function comprises the "analytic model" that will be used for this study. The variables are dictated partly on a priori grounds, and partly from a need to control for extraneous differences among hospitals in the sample.

The cost variable to be used is average cost-per-case. Cost is a comprehensive measure embracing all relevant resource flows within the hospital, including non-salaried physician inputs. Hospital and department cost measures are "average costs" in the sense that the total annual cost at the hospital or department level is divided by a measure of hospital or department rate of annual output. In the present study, total discharges are taken as the measure of hospital output. Case-level analysis uses total case cost as the dependent variable.

Independent Variables

The selection of independent variables is based primarily on the nature of the hypothesized relationship and the objectives of the analysis. Included variables fall into two groups, (1) primary explanatory variables: those factors which, on a priori grounds would be expected to bear directly on costs, and (2) "adjustment" or "control" variables: factors that influence costs and which vary from one hospital (or case) to another, and which must therefore be included in the cost function so as not to incorrectly bias the estimated effects of the major explanatory variables.

Teaching. Since the primary focus here is on the effect of the teaching process, the key explanatory variable will be a measure that satisfactorily describes the teaching activity. Such a measure must also be precise enough to differentiate among the hospitals being investigated. The measure used in the cost function is the resident-to-bed ratio (RBR), the denominator including only occupied beds.

Case-mix. Next to the teaching function, the most important class of variables pertains to case-mix and other descriptors of hospital output. Since all sampled hospitals were "full-service" acute care institutions with no notable areas of specialization, differences in product among the hospitals are likely to be subtle. The nature of variation among cases that might affect costs is suggested by concepts such as "complexity," "severity of illness," and "seriousness of illness."

The usual procedure for differentiating hospitals by case mix is to rate individual cases on a suitable scale and then calculate an index over sample cases. Several measures are used in combination in this analysis.

Length of stay (LOS). A simple index of case mix is given by an average of length of stay (LOS) for a cross-section of a hospital's cases. Higher values should indicate a more expensive mix of cases, other things equal. (This is not to say that cases with greater LOS are always more complicated, serious, or expensive.)

Diagnosis-related Group Cost Weight. The model will use a DRG weight index in all cost functions to be estimated. By construction, DRG weights are measures of average cost for cases within a given group. If DRG weights were precise and a sample of cases were representative, then DRG as an independent variable should explain a large proportion of cost.

Severity of illness. To the extent that cases in the same DRG vary in cost due to factors that can be identified by a severity scale, then including an index based on such a scale should improve the explanatory power of the cost function to be estimated. The model applies an index based on the Severity-of-Illness scoring system developed by Susan Horn. The simple average of a seven item severity inventory is utilized.

Scale. Other studies have included a measure of scale such as the number of the beds or total inpatient days per year to account for scale effects. Although no clear pattern of effect has been demonstrated in these studies, the present analysis includes total inpatient days as an independent variable.

Labor prices. Sample hospitals were located in many different cities across the nation, making necessary adjustments for variations in wage rates.

Other variables. Several variables included in the cost function are not there on clear a priori grounds, but more for pragmatic reasons. Such variables add explanatory power and can be rationalized after the fact. The following variables describing the demographic characteristics of patients in observed hospitals fall into this category.

Medicaid status. This variable indicates whether or not the patient is covered by Medicaid, or in fact has no insurance (i.e., is a "self-payor"). Although Medicaid/non-pay status may be associated with higher ("disproportionate") average treatment costs per case, it is also correlated with many other factors--inner-city location, public/private hospital, and so on, any one of which could account for any explanatory power of this variable.

Age, sex. Age is a factor used in defining some DRGs, and the effect of age on treatment cost not otherwise accounted for should be accounted for to some degree by the inclusion of a severity measure. For these reasons, age as a separate variable would not be expected to provide much further explanatory power. Nevertheless, age is included in some versions of the model and does some-

what improve the results. Sex of patient is included in some versions for the same reason.[3]

Quality of care. One of the more difficult issues in the analysis of hospital costs concerns the effect of "quality of care" measures. One explanation often given for the higher costs of teaching hospitals is that they provide care of a higher quality. This could refer to superior technical skills of the physicians, residents, or nurses, or to more advanced technology applied.

In the interest of accounting for all relevant differences, the study has attempted to measure several aspects of treatment that could be construed as indicating skill differentials. The measures are described below.

The direction of effect is difficult to predict, a priori. More skillful practitioners are said to use resources more economically and sub-standard care is more likely to lead to complications. Both effects suggest that quality and cost are inversely related. On the other hand, the most skillful physicians might be concentrated in hospitals with relatively high teaching intensity and expensive technology, with the result that skill measures correlate with higher cost.

The indicator of quality (or "disquality") to be utilized in the model is an index based on the number of at-risk adverse patient

[3] Age is a continuous variable in the extended case-level model, and employ the mean sample age in the hospital and department-level analyses. Sex will be entered as a dichotomous variable in the extended case-level analyses, taking a value of zero for males and one for females. In the hospital and department-level analyses, the reciprocal of the percentage of patients who are female will be employed. This is done for reasons of econometric fit only. Also, by specifying the latter variable in terms of male patients, the same expected relationship with average cost will be preserved as in the case-level analysis--in other words, unit increase in the sex variable (i.e., a decrease in the percentage of patients who are male) is expected to be associated with higher average costs, all other factors equal.

outcomes that actually occur among sample patients at both the hospital and department levels. The index is based on the number of adverse outcomes that occur as a fraction of total at-risk occurrences among sample patients in the hospital or department. The hospital-level index is further adjusted for mean patient severity of illness in the hospital. Higher values of each index (QHOSPA and QUALITY) imply higher quality of patient care.

Excess capacity. Several earlier studies have found a relationship between cost and measures of excess capacity. Whether such excess capacity is unintentional or, as some have suggested (Cowing, Holtmann and Powers (1983), Joskow (1980)), a planned response to future output or demand uncertainty, the existence of a greater than optimum level of fixed capital would be expected to increase costs. An excess capacity measure used in some versions of the model is one developed by Joskow, a function of the relative difference between the number of beds in the hospital and average daily census.[4]

Summarizing, the specific form of the primary cost function is as follows:

AVGCOST = F(TOTIPDAY RESPERBD, LOS, DRGWEIGHT SEVERITY
PHY-WAGE, TCH-WAGE, RN-WAGE, MEDICAID, AGE, SEX),

where

AVGCOST = average total (combined hospital and physician component) cost (or cost per case);

TOTIPDAY = total annual inpatient days at the hospital level (in case-level and hospital-level functions);

[4] The Joskow measure, JOSKOWK, is defined as
JOSKOWK = (BEDS - ADC)/(ADC)$^{\frac{1}{2}}$.

LOS = length of stay (or average length of stay), in days;

DRGWGT = Medicare cost weight assigned to patient's DRG (or adjusted mean DRG weight);

PHY-WGRT = index of area staff physician wage rates;

RN-WGRT = index of area registered nurse wage rates;

TCH-WGRT = index of technician wage rates;

SEVERITY = patient's mean severity-of-illness score, given by the sum of the seven severity-of-illness dimension scores divided by seven (or, where appropriate hospital or department-level mean severity scores);

RESPERBD = number of residents per bed times 10;

MEDICAID = 1 if Medicaid or self-pay, or percentage of caseload that is Medicaid or self-pay, where appropriate;

AGE = patient age;

SEX = fraction of patients that are female.

It should be mentioned that the measurement of some variables will differ according to whether the variable applies to the hospital-level or case-level regression. Finally, to anticipate the presentation of findings below, it is important to observe that, in consequence of intermediate empirical work, the severity of illness measure was dropped from the hospital-level cost function. This is discussed below.

Statistical Methods

All cost functions have been estimated by ordinary least-squares (OLS) regression techniques. Regression analysis can isolate the effect of any explanatory factor on average cost, controlling for all other factors in the analysis. The OLS technique is especially useful in small-sample situations such as is encountered in the hospital-level analyses. Estimates produced by alternative techniques were found to be comparable.

Results presented here are limited to regressions in which variables were entered in standard format. In exploratory work, a log-linear cost model which fits a straight line to data presented in logarithm form was examined. The results were not substantively different.[5]

[5] The log form reappears below in a section reporting on estimating a special version of the model.

IV. Results

Results for two versions of the model are presented in this section. In Section V, results for a third, special-purpose model are presented. The first of the two models discussed in this section includes only the basic variables. The second model adds variables having a weaker *a priori* claim on inclusion in the cost function.

Hospital-Level Analysis

Table 3 presents the results of the hospital-level regression. Coefficients have been translated into factors expressing the effect on average cost per unit change in the independent variable.

Overall explanatory power of the model is relatively good, with adjusted R-square values (measures of the proportion of cost variation explained) at .59 and .66 for the basic and extended versions respectively. Variable coefficients all have the expected sign except for the RN wage index.

The key result is the appearance of a strong, statistically significant impact of teaching on cost. An increase of resident-to-bed ratio of 0.1 is associated with an increase in average per-case costs of 8 to 10 percent when case mix and other control variables are taken into account. Whereas limited sample size poses a barrier to other coefficient estimates meeting stringent statistical significance tests, the teaching effect stands out, being statistically significant at the .01 probability level.

This result supports the view that teaching *per se* increases costs in a non-trivial manner, other relevant variables having been taken into account. However, it is immediately necessary to acknowledge and discuss the absence of severity of illness in the cost function. The omission stems from the fact that the measure of

TABLE 3

REGRESSION RESULTS, HOSPITAL LEVEL OBSERVATIONS

VARIABLE	UNITS	SAMPLE MEAN	PERCENTAGE CHANGE IN COST PER UNIT CHANGE IN VARIABLE	
			BASIC MODEL	EXTENDED MODEL
Residents per bed	1 per 10 beds	1.6/10 beds	8.39**	10.25**
DRG weight	.1	.87	7.78*	5.42
Length of stay	1 day	7.5	4.72	5.42**
Percent medicaid	Pct. point	11.6	0.886*	1.40**
Physician wage index	1 point	100 = $44.52	5.79*	6.27*
RN wage index	1 point	100 = $11.98	−1.22	−2.58
Tech. wage index	1 point	100 = $7.43	9.62	9.44
Severity	(Not included in hospital-level model.)			
Total Days	1000 days	152.5	.067	.058
Excess Capacity	Index unit	5.67		1.52
Quality of care	Index unit	80.4		.012
Age	1 year	41.7		.061
Percent female	Pct. point	59.2		2.30*

n = 45	Basic Model	Full Model
R − Square =	0.6695	0.7573
Adj. R − Square =	0.5893	0.6568
Avg. Cost = $3066.04		

** Significant at .01 Level
* Significant at .05 Level

severity for the hospital-level analysis was (necessarily) an average over the cases sampled for the hospital. Across the relatively small number of hospitals, the range of variation of average hospital-wide severity is narrow. Moreover, the variation that did exist was correlated with other variables in a way that produced nonsense results in those regressions for which average severity was included. Having already seen the results of the case-level regressions (discussed below) in which severity was found to be a significant explanatory variable, it was determined that, given the range of observations, the most useful specification for a hospital-level cost function was a form omitting severity. It must be stressed that the omission reflects empirical necessity rather than a belief that severity "does not matter;" indeed, the case-level results show that severity does matter. (This has important policy implications noted in a following section.)

The average DRG cost weight exhibited a strong and statistically significant effect on average cost in the basic model. The DRG coefficient dropped by nearly one-third, however, when four secondary variables were in the extended model. In evaluating these results, it is necessary to bear in mind that variables may reflect factors with which they are correlated. For example, the three wage indices taken together may capture not only wages but also a wider range of effects associated with city size.

The Medicaid variable appears to have a statistically significant and relatively strong effect on cost. A one percentage point increase in this variable caused a $27 to $43 increase in overall average cost. Measuring from the mean cost ($3066), this amounts to about one percent expected increase in hospital costs.

Of the secondary factors added in the extended model, only one had a statistically significant effect. On average, a percentage point increase in the female caseload of the hospital was associated with a $70 (or 2.5 percent) increase in average cost.

The quality of care variable appeared to have no appreciable effect on cost at the hospital level. The variable may simply fail as a measure of anything having a systematic effect on cost. A more complete analysis of quality measurement using the extensive data developed from this study is being conducted separately.[6]

The estimated excess capacity coefficient is not statistically significant at even the .05 probability level.

Case-Level Analysis

The second set of results describe the relationship between individual case costs for the randomly selected sample of cases and the independent variables described earlier. The results are shown in Table 4.

As might be expected from the increase in number of observations (from 45 to over 13,000), more variables are found to be significantly different from zero using the .01 probability test. Besides the teaching variable, we find the DRG weight, two wage rates, and the severity variable significant at the .01 level in both the basic and extended model.

It will be noted that the coefficient estimates for the basic model variable set are remain nearly unchanged when variables of the extended model are added. The is true even though one of the latter, sex, is statistically significant and relatively important in effect on cost.

A major finding is that severity of illness appears with a statistically significant effect on cost. A 0.1 increase in the severity index, which amounts to about 7 percent of the mean severity over

[6] A separate report covers case mix and quality of care measures tested in the GME Study. See preface for a reference to this report.

TABLE 4

REGRESSION RESULTS, CASE LEVEL OBSERVATIONS

VARIABLE	UNITS	SAMPLE MEAN	PERCENTAGE CHANGE IN COST PER UNIT CHANGE IN VARIABLE	
			BASIC MODEL	EXTENDED MODEL
Residents per bed	.1 res/bed	.157 res/bed	7.27**	7.25**
DRG weight	.1	.876 (abs.)	7.65**	7.81**
Length of stay	1 day	7.47	4.98**	4.97**
Percent medicaid	Pct. point	11.65	0.099	.110
Physician wage index	index point	100 = $44.64	5.05**	4.99**
RN wage index	index point	100 = $11.97	1.08	.820
Tech. wage index	index point	100 = $7.47	11.97**	12.03**
Severity	.1 index point	1.467	3.15**	3.32**
Total Days	1000 days	151.8	.015	.014
Excess Capacity	index point	5.75		.296
Quality of care	Index unit	80.0		−.01
Age	1 year	41.5		−.068
Percent female	Pct. point	59.23		10.37*

n = 13,436	Basic Model	Full Model
R − Square =	0.5407	0.5422
Adj. R − Square =	0.5404	0.5418
Avg. Cost = $4149.61		

** Significant at .01 Level
* Significant at .05 Level

all observations, produces a 3.15 percent increase in cost (3.32 percent for the extended model). This effect is found even after taking into account DRG weight and length of stay, the coefficients of which are statistically significant and relatively large.

The coefficients estimated for DRG weight and LOS using the case-level data are about the same as were estimated using hospital-level data. At the same time, the coefficient for the resident-to-bed ratio has diminished by nearly one-third, compared to the hospital-level results.

One straightforward explanation for this result follows from the effect that a correlation between severity and teaching intensity would have in the hospital-level regression from which severity has been omitted. (As noted earlier, inclusion of severity in the hospital-level equation led to implausible results.) The omission would bias the estimate of the teaching coefficient upward. A comparison of results from the hospital and case-level regressions suggests that the latter yields the more acceptable coefficient estimate for resident-to-bed ratio.

Other variables. Although wage rates are measured at the hospital level, their strong effect on case level costs can be inferred from the regression results. Looking ahead to results from the special model discussed later, one is led to speculate that city size, a variable not included in these models, has an important bearing on cost. If that is true, then if technician wages and city size are also correlated, the substantial wage index coefficient reflects an effect ascribable in part to city size.

The Medicaid variable, although it appeared to have a small but significant effect at the hospital level, has no apparent explanatory value at the case level. How this might tie in with the introduction of severity is open to speculation.

In addition to the technician wage coefficient, the coefficient estimate for sex, (one percentage point in percent female yielding a 10.37 percent cost increase) seems unexpectedly large.

Overall explanatory power is relatively good at the case level. About 54 percent of the variation in average cost is explained.

Policy Implications

The results indicate clearly that teaching exerts an independent upward effect on cost. After taking into account other relevant variables, including case-mix measures enhanced by the addition of a separate severity-of-illness measure, teaching intensity, measured by resident-to-bed ratio, produced somewhat more than a 7 percent increase in overall cost per case for each addition of 0.1 resident per bed. The size of the effect is comparable to earlier estimates, as will be discussed at greater length in a later section. Referring back to the introductory discussion, the results contradict the view that resident labor input fully offset the higher costs due to the GME process (such as extra tests) and not to correlated factors such as case-mix or severity.

In drawing comparisons with other estimates, it should be borne in mind that the cost variable includes an imputed value of separately-billed physician costs, a component amounting to about 20 percent of total cost for the average case. To the extent that the physician component is relatively constant with respect to teaching intensity (Cameron, 1985), the larger cost base would tend to reduce the measured teaching coefficient, compared to estimates derived from data that did not include the physician component of cost.

It should be noted that the finding from the case-level analysis that severity does have an effect on cost dominates the ambiguity regarding severity in the hospital-level analysis. It should not be inferred that severity can be ignored for purposes of hospital

reimbursement. The findings suggest, instead, that under current circumstances the mix of cases in hospitals is such that the overall severity average for a hospital does not vary systematically with teaching intensity. However, if, as the case-level results indicate, severity does explain a portion of the cost variation, then ignoring that relationship in any reimbursement mechanism would introduce an underpayment bias with respect to severe cases, and that bias would cause hospitals to avoid underpaid cases as far as that were practicable.

V. Indirect Cost of Graduate Medical Education

This section reports on a special cost analysis designed to contribute to current policy research on a topic of continuing interest to federal policy-makers.

Federal payments to teaching hospitals for services delivered to Medicare patients occur in two componets. The first component reimburses for Medicare's share of costs directly attributable to the GME process, mainly stipends paid to interns and residents and a portion of faculty salary. The second component is a subsidy based on the hospital's resident-to-bed ratio (RBR). This component, called the "indirect cost adjustment," is determined according to a formula that increases the base payment amount by a factor proportional to the RBR. The formula, derived from a cost analysis performed by the Health Care Financing Administration (HCFA), is described in Lave (1985).

As the name suggests, the "indirect cost adjustment" is intended to compensate for the higher "indirect costs" confronted by teaching hospitals. In this application, "indirect costs of teaching" refer to the higher costs associated with teaching hospitals after taking into account certain other variables. The historical rationale for this component of payment is rooted in the idea that teaching induces higher costs, but factors other than teaching per se have been cited as justification for the differential subsidy (Senate Finance Committee, 1983).

Anderson and Lave (1986) suggest, on the basis of further cost analysis, that the HCFA payment formula gives too much weight to RBR and not enough to other factors, especially central city location and more severe case mix, which contribute to higher costs.

The analysis here uses the GME Study data in a model comparable to the models used by HCFA and by Anderson and Lave. The comparison

of findings should be useful as a point of reference for further work.

The indirect cost of GME can be estimated statistically through the use of a hospital cost function. A key difference between this function and those discussed earlier in this report relates to the measurement of cost per case (i.e., the dependent variable).

> Measurement of cost. (1) In order to isolate the "Medicare indirect cost effect" of GME, cost per case is determined from the subset of Medicare cases only. (2) Direct costs attributable to teaching, research and capital are subtracted from costs.

The first of four forms of the model to be estimated is designed along the lines of the current Medicare payment formula, but is not identical to it in all respects. In this model, a hospital's Medicare operating cost per case is assumed to depend on the hospital's case mix, teaching intensity, the wages it pays to hospital workers (specifically nurses and technicians) and the size of the Metropolitan Statistical Area (MSA) in which the hospital is located. Case mix is measured through an index derived from standardized DRG cost weights, while teaching intensity is measured by the ratio of interns and residents to occupied beds at each hospital.

Although the antecedent research of indirect teaching costs has incorporated a single wage variable, we obtained better results using separate wage indices for nurses and technicians which tended to be more stable than using a single index derived from the wages of all hospital workers.[7]

[7] Most likely this is due to the small size of the hospital sample and the relatively small variation in wage rates that we observed throughout the sample.

The current indirect teaching adjustment formula used by Medicare is designed to reimburse urban hospitals at a higher rate than rural hospitals, all other factors equal. There is reason to believe, however, that the size of urban areas is also important. Pettengill and Vertrees (1982), for example, found strong evidence that hospital costs are directly related to MSA size. We have used four size categories in our model: urban populations greater than 500,000 (SIZE1), between 250,000 and 500,000 (SIZE2), less than 250,000 (SIZE3), and rural.[8]

Each of the three subsequent models extends this basic model by adding a key independent variable. The second model adds the hospital's mean severity index to the analysis; the third model also adds a "social severity" measure (the hospital's Medicaid/no pay caseload as a percentage of total discharges), while the fourth model further adds hospital bedsize (a surrogate for scale used by HCFA in its 1982 regression analysis of Medicare operating costs).

All variables except those related to MSA size were measured in logarithmic form, following the methodology of related work in this area. Because the non-teaching hospitals in the sample have a zero RBR value, RBR is transformed to 1 + RBR before taking the logarithm. Estimation was by ordinary least-squares.

The results presented in Table 5 are relatively stable across the four regression models, with some exceptions. In all instances, however, the instability was confined to variables with statistically insignificant effects on cost. The DRG case mix index and the residents-to-bed ratio proved to be statistically significant at the 95% confidence level in all models. Aside from these two, however, the only other consistently significant effect on cost was location in an MSA with population greater than 500,000. (It

[8] For econometric reasons, one category, here the rural category, is excluded as an explicit variable in order to provide a point of reference for the other categories.

TABLE 5

REGRESSION RESULTS FOR INDIRECT COST MODELS

VARIABLE	ESTIMATED COEFFICIENTS*			
	REGRESSION NUMBER			
	1	2	3	4
ln Residents Per Bed	0.758 (.27)	0.723 (.28)	0.694 (.29)	0.688 (.28)
ln DRG Case-Mix Index	1.09 (.25)	1.08 (.31)	1.02 (.35)	1.01 (.35)
ln Nurse Wage Index	0.446 (.49)	0.415 (.49)	0.514 (.51)	0.851 (.55)
ln Technician Wage Index	−0.07 (.61)	−0.05 (.62)	−0.12 (.63)	−0.43 (.65)
Size 1	0.201 (.11)	0.213 (.11)	0.208 (.11)	0.299 (.13)
Size 2	0.008 (.10)	0.017 (.10)	0.013 (.11)	0.066 (.11)
Size 3	0.019 (.12)	0.026 (.12)	0.015 (.12)	0.032 (.12)
ln Severity Index		0.580 (.92)	0.614 (1.05)	0.476 (1.06)
ln Medicaid Index			0.037 (.04)	0.039 (.04)
ln Beds				−0.110 (.08)
R-Squared	.64	.65	.66	.68
Intercept	7.334	7.136	7.144	7.402

*Values in parentheses are standard errors of coefficient estimates.

should be noted that the likelihood of detecting significant effects is limited by the size of the sample.)

The models explain roughly two-thirds of the observed differences in direct Medicare costs. The results from regression (1), which uses a combination of independent variables similar to those used in the HCFA analysis, indicate that a one percent increase in the variable 1+RBR is associated on average with slightly more than three-quarters of one percent higher Medicare operating costs per case. At the GME sample RBR mean of .157 residents per bed (see Table 4 above), a 1 percent increase of 1 + RBR, which corresponds to a 7.37 percent increase in RBR, is associated with a .758 percent increase in Medicare operating cost.[9]

The elasticity of approximately .7 (7 percent increase in cost associated with a 10 percent increase in 1+RBR) may be compared to earlier estimates by others using similar combinations of variables. HCFA originally estimated the elasticity of 1+RBR to be .579. (This was translated, by substitution of average RBR into the 1+RBR variable, into a prescribed reimbursement adjustment of 5.79 percent per .1 increase in RBR.) Anderson and Lave find elasticity values ranging from a high or .81 to a low of .47, specific values depending on the suite of independent variables included in the regression equation.

Since the DRG case mix index is based on standardized DRG cost weights, we would expect the estimated effect of this variable on cost to be approximately one. The estimate converges toward one as more variables are included in the analysis. This result is

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[9] In the prior linear model reported in Table 4, in which the dependent variable was total costs per case, a unit increase in RBR, .1 residents per bed, was found to induce a 7.2 percent increase in cost. A unit increase, in the formulation of that model, is a 63 percent increase. To summarize, a 63 per cent RBR increase in the linear model induces a 7.2 percent total cost increase, while a 7.37 percent RBR increase in the log-log model induces a .758 percent increase in Medicare operating cost. The magnitudes are similar, as one would expect.

similar to the results of Anderson/Lave. Another similarity is the finding that costs increase with city size. Hospitals located in MSA's with populations greater than 500,000 appear to have systematically higher Medicare direct costs per case than the rural hospitals in the GME results.

Some differences between the GME results and Anderson/Lave are worth noting. The GME sample produced an anamolously weak estimated wage effect (approximately a .4 elasticity for the sum of separate nurse and technician wage indices, compared to an approximate unity estimate for Anderson/Lave), a result which may account for the fact that Anderson/Lave's teaching effect coefficients are considerably lower than the GME estimate for the most closely comparable equations. The alternative explanation that the GME regression includes severity is not convincing, inasmuch as the addition of that variable reduces the RBR elasticity only from .758 to .723.

Anderson/Lave find a stronger Medicaid effect--.19 versus .03 elasticity with respect to percent Medicaid/no pay. However, the difference must be viewed in combination with the GME's inclusion of a severity variable. The combination of a nontrivial severity impact, a weak Medicaid effect, and a perverse and small coefficient for bedsize (see equation number 4 in Table 5) would appear to lend credance to Anderson/Lave's speculation that in their model Medicaid and bedsize are operating as proxies for severity.

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